



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification <sup>5</sup> : G01J 3/50, A61C 19/10</p>	<p>A1</p>	<p>(11) International Publication Number: <b>WO 91/02955</b> (43) International Publication Date: 7 March 1991 (07.03.91)</p>
<p>(21) International Application Number: PCT/GB90/01288 (22) International Filing Date: 15 August 1990 (15.08.90) (30) Priority data: 8918605.0 15 August 1989 (15.08.89) GB (71)(72) Applicant and Inventor: McKEOWN, Sameul, Thomas, John [GB/GB]; 36 Annetyard Drive, Skelmorlie, Renfrewshire PA17 5BN (GB). (74) Agent: PACITTI, Pierpaolo, A., M., E.; Murgitroyd and Company, Mitchell House, 333 Bath Street, Glasgow G2 4ER (GB).</p>		<p>(81) Designated States: AT (European patent), BE (European patent), CA, CH (European patent), DE (European patent)*, DK (European patent), ES (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.  Published <i>With international search report.</i></p>
<p>(54) Title: SHADE DISTINGUISHING DEVICE</p> <div data-bbox="427 1251 1195 1570" data-label="Image"> </div> <p>(57) Abstract</p> <p>A shade distinguishing device comprising a casing (6) having a light source (1) and detector (2). The light source and detector being relatively positioned so that a proportion of the light emitted by the detector, and falling incident on an object, is reflected onto the detector. The proportion of the light detected being dependent on the colour and shade of the object. The signal from the detector being processed to produce an accurate signal representative of the shade and colour of the object, which is displayed on a liquid crystal display (3).</p>		

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1    "Shade Distinguishing Device"

2

3    This invention relates to a shade distinguishing  
4    device.

5

6    In addition to the primary task of caring for patients'  
7    teeth and gums dentists today also have to be aware of  
8    the cosmetic side of their work. Patients whether they  
9    require fillings, caps, veneers or dentures want them  
10   to blend and match their own teeth. The most important  
11   part of this matching process is colour or shade  
12   matching.

13

14   At present shade matching is achieved by a dentist who  
15   visually matches the shade of a patients' teeth with a  
16   16 shade guide. This is both an extremely time  
17   consuming and an inadequate process. With only 16  
18   shades to choose from many patients' teeth cannot be  
19   matched perfectly. This problem is compounded both by  
20   dentists not always having time for an accurate  
21   matching and by the shading on the charts fading with  
22   age. These problems added to the fact that many  
23   dentists and technicians do not have perfect colour  
24   vision results, in many cases in an extremely poor  
25   shade match and visually obvious dental work for the

1 patient.

2

3 The provision of a device which can provide an accurate  
4 measure of teeth shading is therefore extremely  
5 desirable.

6

7 According to the present invention there is provided a  
8 shade distinguishing device comprising a light source  
9 for projecting light towards an object, light detecting  
10 means for receiving light reflected from said object  
11 and which produces an output signal the magnitude of  
12 said signal being dependent on the intensity of light  
13 incident on the detecting means and means for producing  
14 an audio or visual display representative of the  
15 magnitude of said signal.

16

17 Preferably, the light source is a light emitting diode.

18

19 Most preferably, there is a plurality of light sources,  
20 each producing light at a different wavelength,  
21 particularly in the ranges including red, yellow, green  
22 and blue light.

23

24 Preferably, the detecting means is a diode which  
25 produces a voltage signal the magnitude of the signal  
26 being dependent on the intensity of the incident light.

27

28 Preferably, the detector is shielded in order to limit  
29 the detection of scattered or spurious light.

30

31 Preferably, signals produced by the detection of  
32 spurious light are deleted by the modulation of the  
33 light source at a known frequency and the use of phase  
34 sensitive detection of the reflected light, at the said  
35 frequency.

1 Most preferably phase sensitive detection is provided  
2 by the inclusion of a lock-in amplifier system.

3  
4 Preferably, the light source and detector are  
5 relatively positioned so that light emitted by the  
6 source will be detected by the detector only if the  
7 light is reflected from a surface at a set distance  
8 from the light source and detector.

9  
10 Most preferably, the surface is a tooth and the  
11 intensity of light on the detector is dependent on the  
12 proportion of the light, incident on the tooth, which  
13 is reflected by the tooth enamel.

14  
15 Preferably, the signal is processed by an analogue to  
16 digital converter to drive a digital display.

17  
18 Most preferably, the analogue to digital converter is  
19 in the form of a pre-programmed micro-chip.

20  
21 Preferably, the digital display is a seven segment  
22 liquid crystal display.

23  
24 An embodiment of the present invention will now be  
25 described, by way of example, with reference to the  
26 accompanying drawings in which:

27  
28 Fig. 1 is a side elevation of a shade  
29 distinguishing device in accordance with the  
30 present invention;

31 Fig. 2 is a plan view of the shade  
32 distinguishing device of Fig. 1; and  
33 Fig. 3 is a block diagram of the shade  
34 distinguishing device of Fig. 1.

35

1 Referring to the drawings, Figs. 1 and 2 show a shade  
2 distinguishing device including a plastics housing 6  
3 one end of which is attached to an operating head 7  
4 containing a light source in the form of a light  
5 emitting diode 1 and a light detector 2 in the form of  
6 a diode which produces a voltage signal the magnitude  
7 of the signal being dependent on the intensity of the  
8 light incident on the detector 2. The main body of the  
9 housing 6 contains a means of processing the signal, in  
10 the form of a pre-programmed micro-chip which converts  
11 the analogue signal produced by the detector 2 to a  
12 digital signal which is displayed on an array of three  
13 liquid crystal diodes 3.

14

15 Fig. 3 is a block diagram showing how the shade  
16 distinguishing device will show a unique number on the  
17 display corresponding to the colour and shade of the  
18 object under test.

19

20 The sample is illuminated sequentially by various  
21 colour light emitting diodes and the light reflected  
22 back from the sample is measured using a photodiode.

23

24 In any practical measurement the signals will be  
25 accompanied by unwanted noise energy that limits the  
26 sensitivity that can be obtained. An a.c. phase  
27 sensitive measurement system is used in order to  
28 improve the signal to noise ratio and provide some  
29 immunity to strong light entering the detector. The  
30 phase sensitive detector has the ability to resolve a  
31 signal from broadband noise many times the amplitude of  
32 the signal to be measured. A lock-in amplifier  
33 measurement system is used which incorporates a  
34 modulation circuit, selective amplification,  
35 synchronous demodulation and low pass filtering.

1 The light emitting diodes are modulated at a discreet  
2 frequency in a region of minimal noise well removed  
3 from low frequency flicker noise and interference such  
4 as mains pick-up. Logic circuitry sequentially turns  
5 on each light emitting diode for a short period in  
6 turn. A driver circuit is used to provide sufficient  
7 current drive to the light emitting diodes.

8  
9 The signal from the detector first undergoes wideband  
10 filtering and amplification. A band pass filter is  
11 used to remove any large interference signals which  
12 could saturate the output of the phase detector.

13  
14 The modulated signal is synchronously detected using  
15 the reference signal to form the product in a  
16 multiplier circuit. This enables the system to  
17 discriminate against random noise components. The  
18 reference signal is derived from the same source as the  
19 signal and must be phase coherent. The output from the  
20 synchronous detector is then converted to a d.c. signal  
21 by an integrator and low pass filter. This provides a  
22 narrow bandwidth and removes any higher order a.c.  
23 components in the signal. The d.c. signal is then  
24 converted to a digital code using an analogue to  
25 digital convertor. At the end of conversion the output  
26 from the A/D convertor is latched into a shift register  
27 for storage.

28  
29 A separate shift register is used for each light  
30 emitting diode. The outputs from the shift registers  
31 are connected to the address lines of then memory  
32 device and are used to select a unique address on the  
33 chip. The address selected will therefore depend on  
34 the level of the measurement signal. The memory device  
35 is pre-programmed with a unique number in each

1 location. The memory devices are configured as READ  
2 ONLY and therefore the data lines will correspond to  
3 the binary code of the location selected by the address  
4 lines. The data from the memory device is processed  
5 into a suitable form for the digital display which is  
6 updated at the end of each cycle of measurements.

7  
8 The means of actuating the shade distinguishing device  
9 is in the form of an operating button 4.

10  
11 In use a dentist or other user would place the open end  
12 5 of the operating head 7 over a patients' tooth, thus  
13 positioning the light emitting diode 1 and light  
14 detector 2 at a set distance from the tooth. In this  
15 way the maximum amount of light emitted by the diode 1  
16 and reflected off of the tooth falls incident on the  
17 detector 2.

18  
19 The light incident on the tooth is either absorbed,  
20 transmitted or reflected. The proportion of the light  
21 reflected is dependent on the shade of the tooth; a  
22 black tooth reflecting no light and a pure white tooth  
23 reflecting all of the incident light. Therefore, the  
24 proportion of the light reflected is determined by the  
25 shade of the tooth and the voltage signal produced by  
26 the detector is determined by the intensity of this  
27 light incident on the detector.

28  
29 Thus the voltage signal produced by the detector  
30 provides an accurate measure of the shade of a tooth.  
31 The voltage signal is converted from an analogue to a  
32 digital signal for ease of display, using a three digit  
33 liquid crystal diode display 3.

34  
35 The voltage signal provided by the shade distinguishing



1 device can be compared to the signal obtained from each  
2 of the 16 shades available from a Vita (TM) shade  
3 guide. As the shades of porcelain produced by Vita  
4 (TM) and other manufacturers increase the electronic  
5 shade indicator will enable the exact matching of any  
6 tooth shade to that of a porcelain, which can be used  
7 to produce dentures or crowns or other dental  
8 requirements.

9  
10 In this way the introduction of a shade distinguishing  
11 device in accordance with the present invention not  
12 only enables more accurate use of the presently  
13 available shades of porcelain but also facilitates the  
14 introduction and use of a much wider range of shades of  
15 porcelain.

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17 Modifications and improvements may be incorporated  
18 without departing from the scope of the invention.

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1   Claims

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3   1.   A shade distinguishing device comprising a light  
4   source for projecting light towards an object, light  
5   detecting means for receiving light reflected from said  
6   object and which produces a signal, the magnitude of  
7   said signal being dependent on the intensity of light  
8   incident on the detecting means and means for producing  
9   an audio or visual display representative of the  
10  magnitude of said signal.

11

12  2.   A shade distinguishing device as claimed in Claim  
13  1, wherein the light source is a light emitting diode.

14

15  3.   A shade distinguishing device as claimed in Claim  
16  2, wherein the device includes a plurality of light  
17  emitting diodes each providing light at a different  
18  wavelength, thus allowing the device to distinguish  
19  between colours.

20

21  4.   A shade distinguishing device as claimed in Claim  
22  3, wherein a logic circuit is provided to operate each  
23  light emitting diode in sequence.

24

25  5.   A shade distinguishing device as claimed in any  
26  preceeding claim, wherein the detector is shielded in  
27  order to limit the detection of scattered or spurious  
28  light.

29

30  6.   A shade distinguishing device as claimed in any  
31  preceeding claim, wherein the signals produced by  
32  scattered or spurious light are deleted by the  
33  modulation of the light source at a known frequency and  
34  the use of phase sensitive detection of the reflected  
35  light at the said frequency.

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2 7. A shade distinguishing device as claimed in Claim  
3 6, wherein a lock-in amplifier system is used.

4

5 8. A shade distinguishing device as claimed in any  
6 preceeding claim, wherein the light source and detector  
7 are relatively positioned so that light emitted by the  
8 light source will be detected by the detector only if  
9 the light is reflected from a surface at a set distance  
10 from the light source and detector.

11

12 9. A shade distinguishing device as claimed in Claim  
13 8, wherein the surface is a tooth and the intensity of  
14 light incident on the detector is dependent on the  
15 proportion of the light, incident on the tooth, which  
16 is reflected by the tooth enamel.

17

18 10. A shade distinguishing device as claimed in any  
19 preceeding claim wherein the signal is processed by an  
20 analogue to digital convertor in the form of a  
21 pre-programmed micro-chip, to drive a digital display.

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23 11. A shade distinguishing device as claimed in any  
24 preceeding claim, wherein the device is powered by a  
25 power cell such as a battery.

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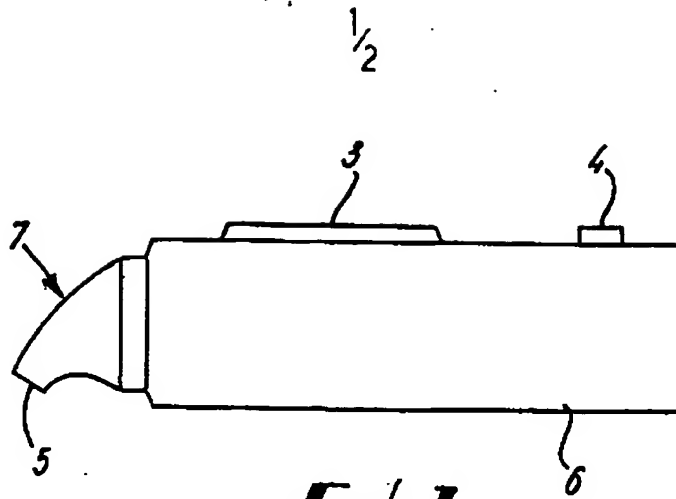
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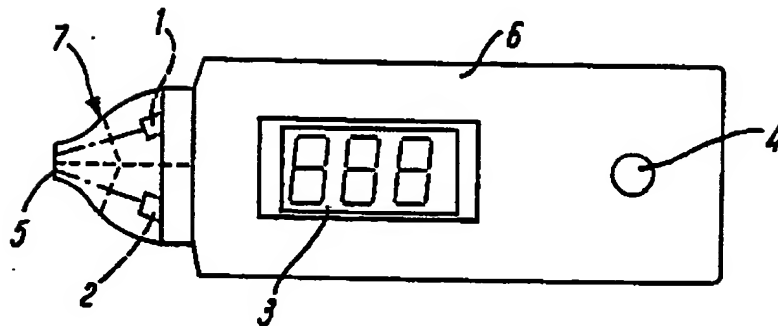
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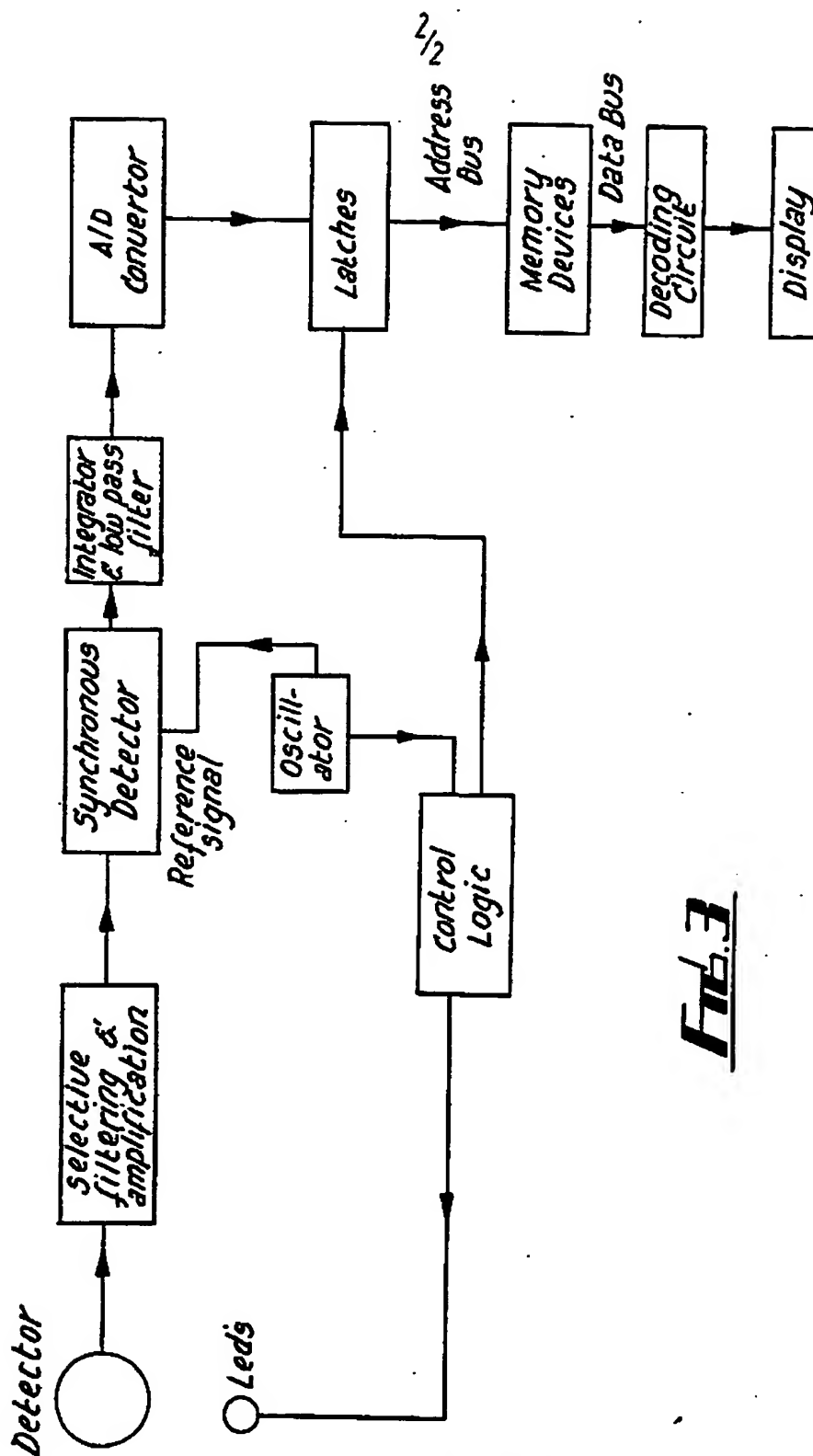


**FIG. 1**



**FIG. 2**


SUBSTITUTE SHEET

**Fig. 3**

SUBSTITUTE SHEET

# INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 90/01286

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) *		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC <sup>5</sup> : G 01 J 3/50, A 61 C 19/10		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
IPC <sup>5</sup>	G 01 J, A 61 C	
Documentation Searched other than Minimum Documentation to the extent that such Documents are included in the Fields Searched <sup>8</sup>		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT <sup>9</sup></b>		
Category <sup>10</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
P,X	EP, A, 0360657 (BERTIN & CO) 28 March 1990 see column 4, lines 2-51; figure 1 --	1,9,10
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<p>* Special categories of cited documents: <sup>14</sup></p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"I" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"A" document member of the same patent family</p>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
12th November 1990	13. 12. 90	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	F.W. HECK 	

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
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**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 05/12/90. The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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